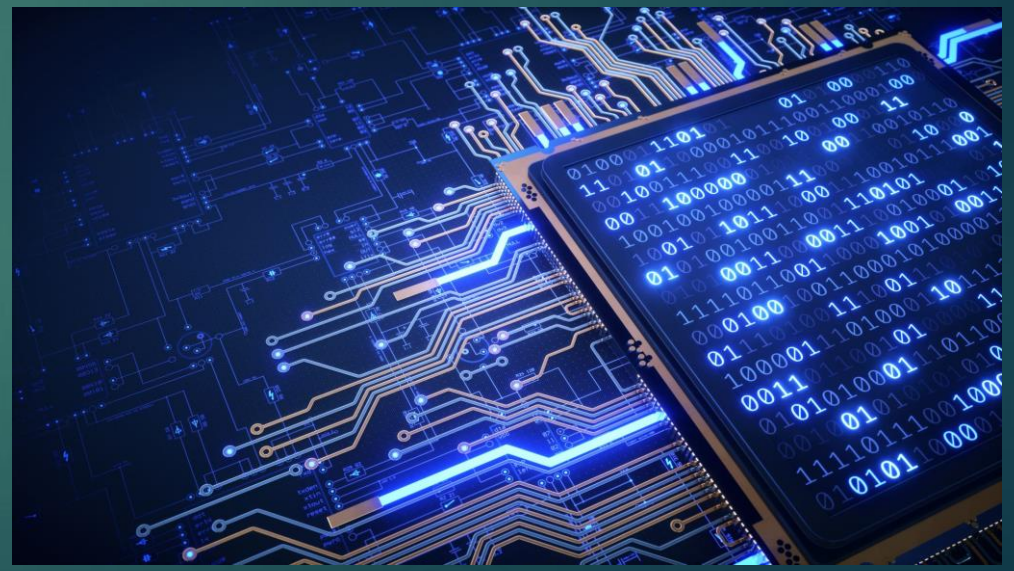
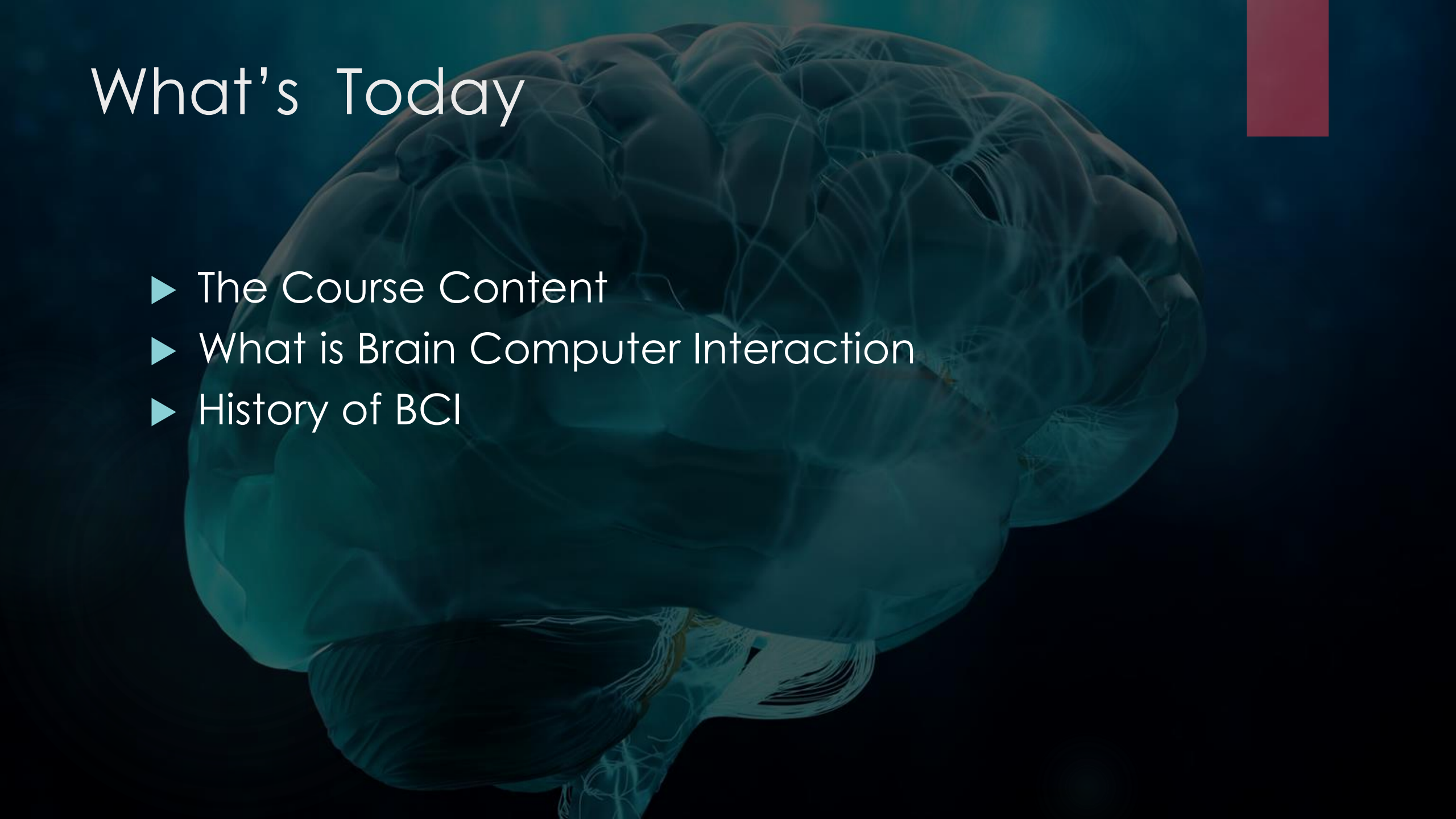
Brain Computer Interaction

Introduction to BCI

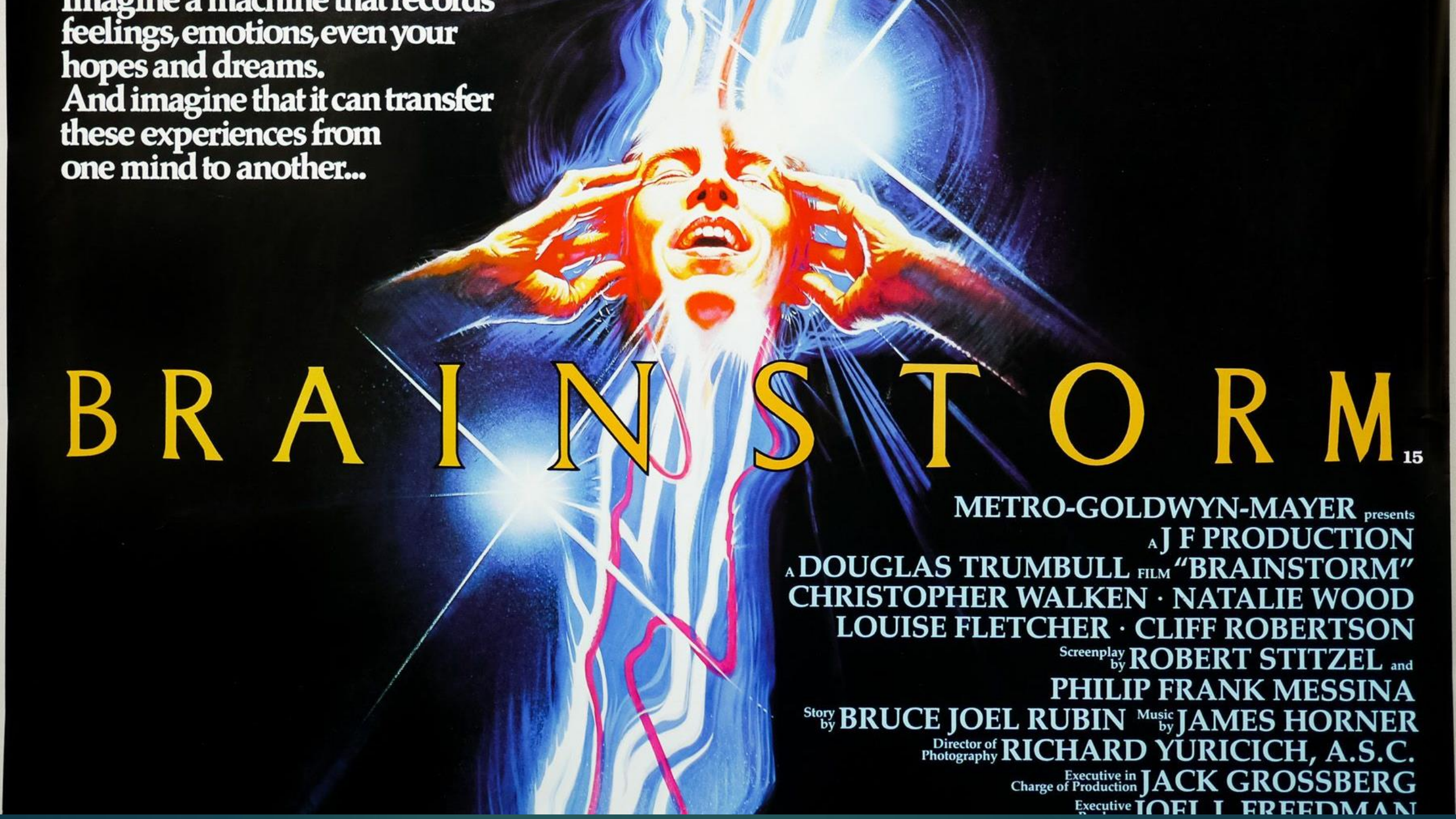


What's Today



- The Course Content
- What is Brain Computer Interaction
- History of BCI

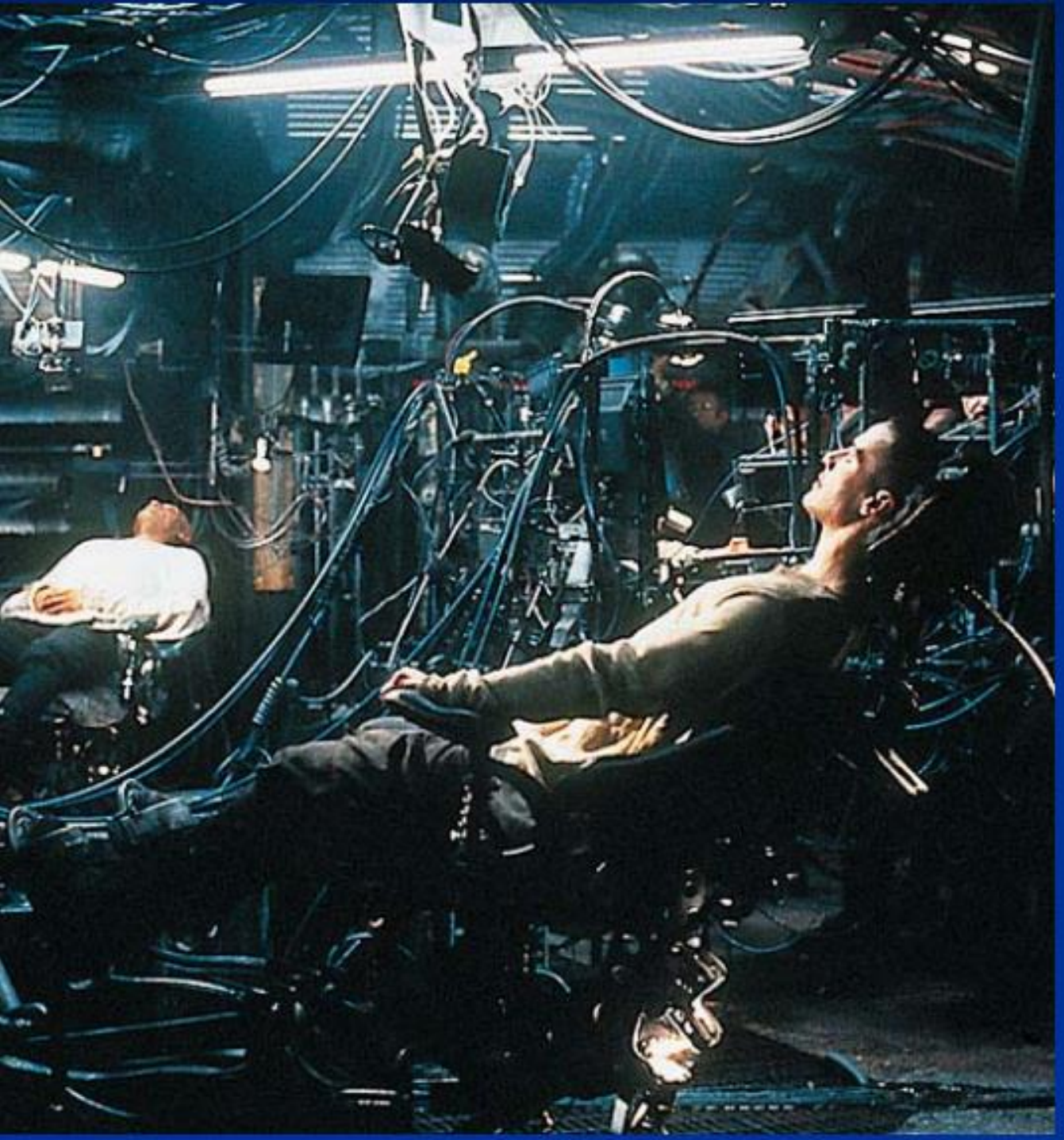
Imagine a machine that records feelings, emotions, even your hopes and dreams.
And imagine that it can transfer these experiences from one mind to another...

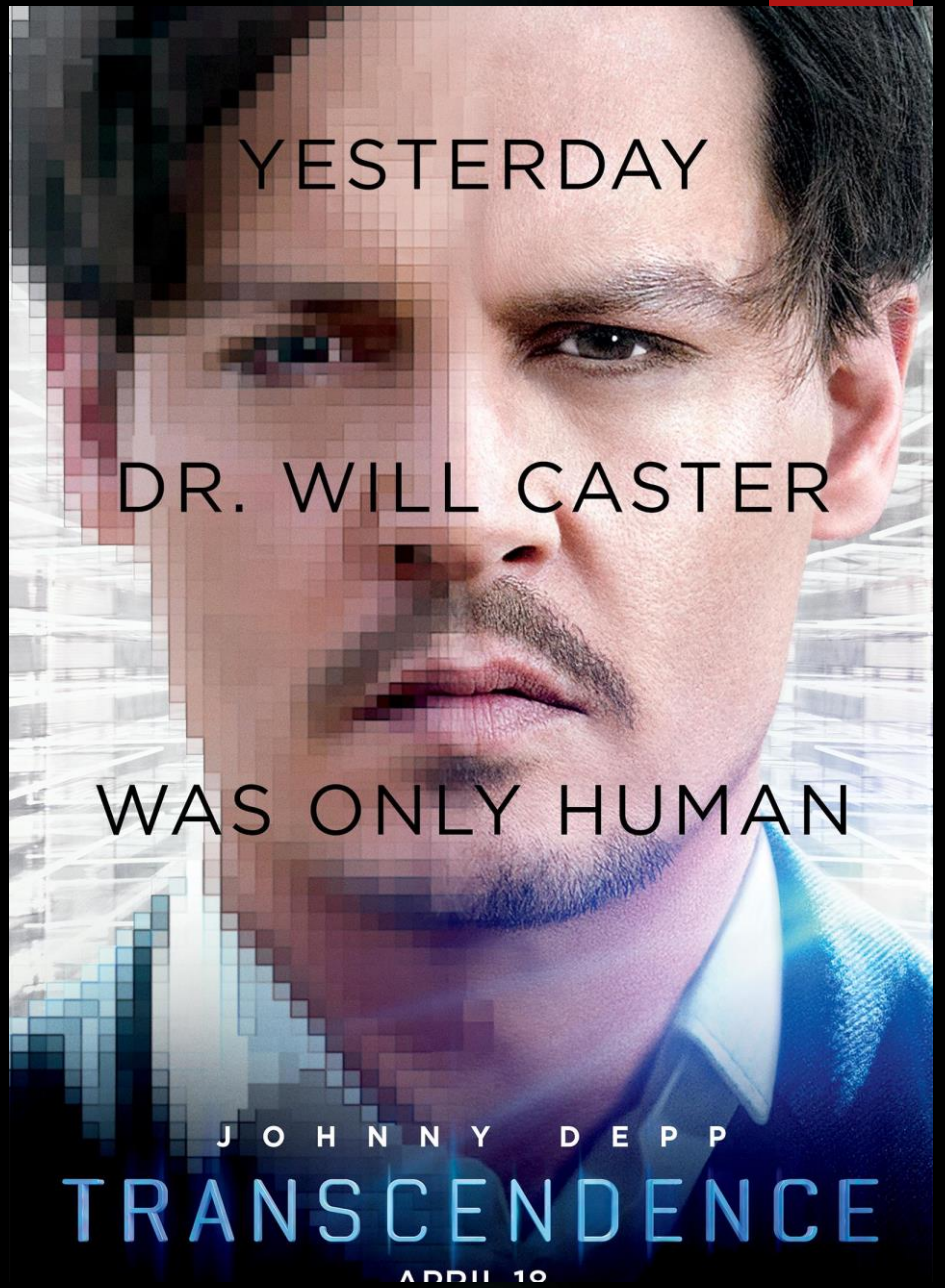


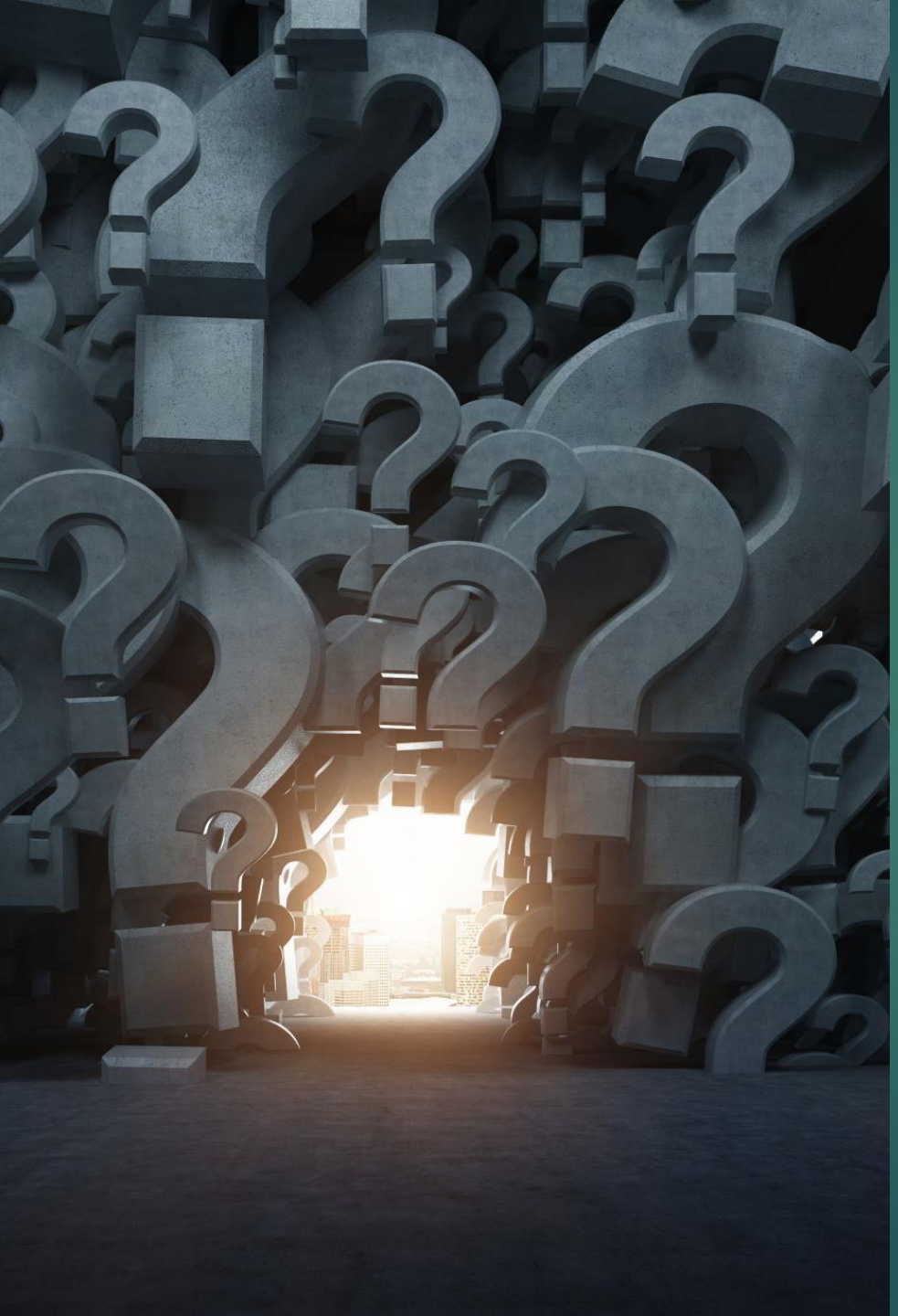
BRAINSTORM

15

METRO-GOLDWYN-MAYER presents
A J F PRODUCTION
A DOUGLAS TRUMBULL FILM "BRAINSTORM"
CHRISTOPHER WALKEN · NATALIE WOOD
LOUISE FLETCHER · CLIFF ROBERTSON
Screenplay by ROBERT STITZEL and
PHILIP FRANK MESSINA
Story by BRUCE JOEL RUBIN Music by JAMES HORNER
Director of Photography RICHARD YURICICH, A.S.C.
Executive in Charge of Production JACK GROSSBERG
Executive JOEL L. FREEDMAN




YESTERDAY
DR. WILL CASTER
WAS ONLY HUMAN
JOHNNY DEPP
TRANSCENDENCE



Is it FICTION or is it POSSIBLE???

Syllabus

Unit – 1 *Introduction to Brain Computer Interface*

Unit – 2 *Introduction to Basic Neuroscience*

Unit – 3 *Modelling and Recoding of the Brain Signals*

Unit – 4 *Signal processing*

Unit – 5 *Signal Analysis using Machine Learning Approaches*

Unit – 6 *BCI Applications*

Course Assessment

- Mid Sem
- End Sem
- Quizzes
  - Surprise Quiz
  - Scheduled Quiz
- Projects
  - Knowledge of Python or MATLAB required

Motivation for BCIs

Potential for restoring lost sensory and motor function

To control prosthetic devices such as prosthetic arms or legs for amputees and patients with spinal-cord injuries

Wheelchairs for paralyzed individuals

Cursors and word spellers for communication by locked-in patients

Sensory prosthetic devices such as cochlear implant for the deaf, retinal implant for the blind

More recently, researchers have begun exploring BCIs for able-bodied individuals for a host of applications such as Game, Entertainment to robotic avatars, biometric identification and Education.

Users

Novice user

Language illiterate

Blind user

Old-age people

Disabled user

Brain Computer Interface

- A system which translates thoughts and provides an interface used for communication called as Brain Computer Interface (BCI)
- A typical BCI system comprises of signal acquisition system, signal processing (feature extraction and classification) and an output device

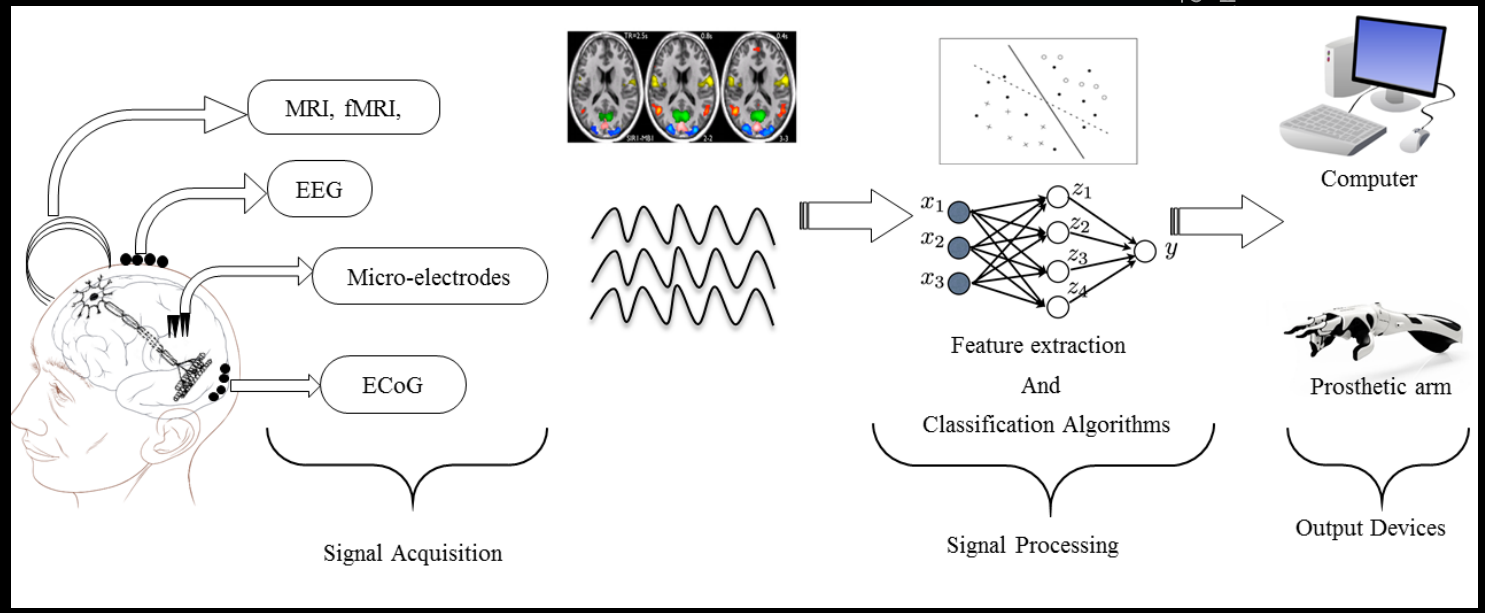
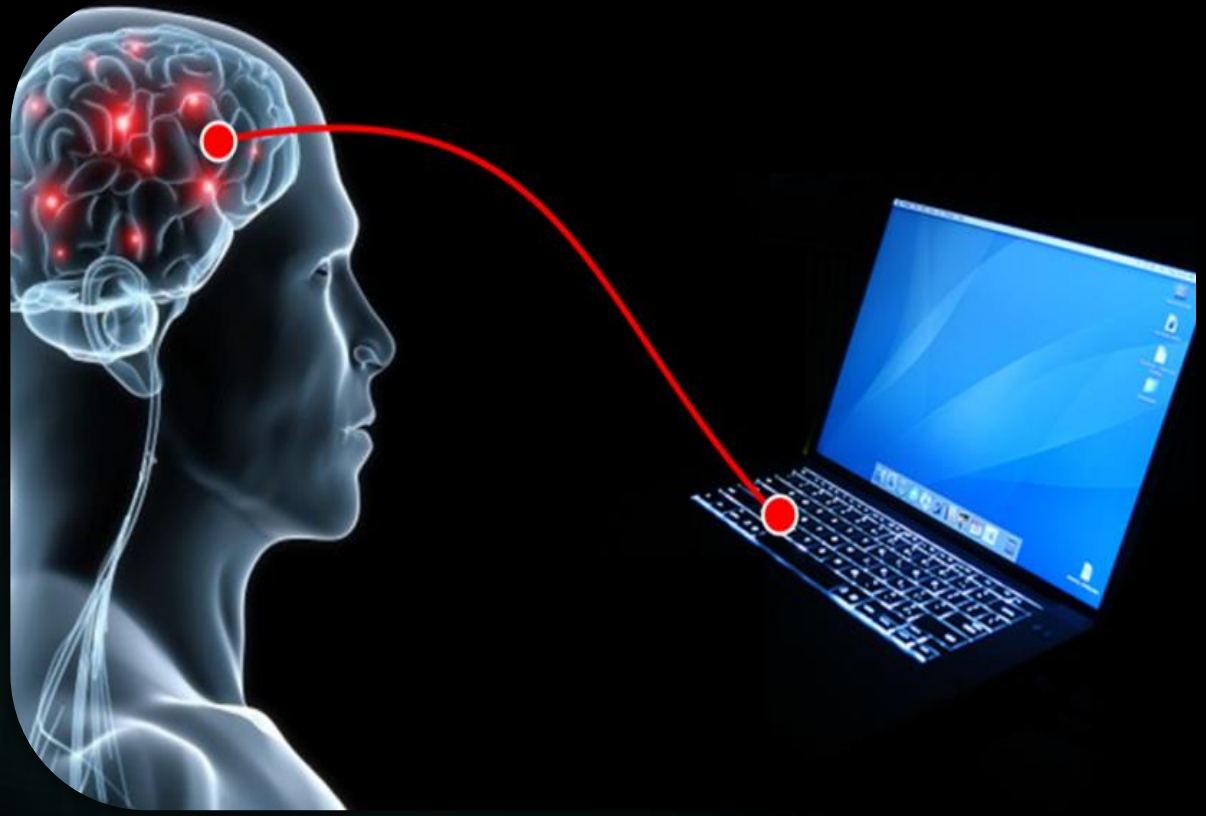
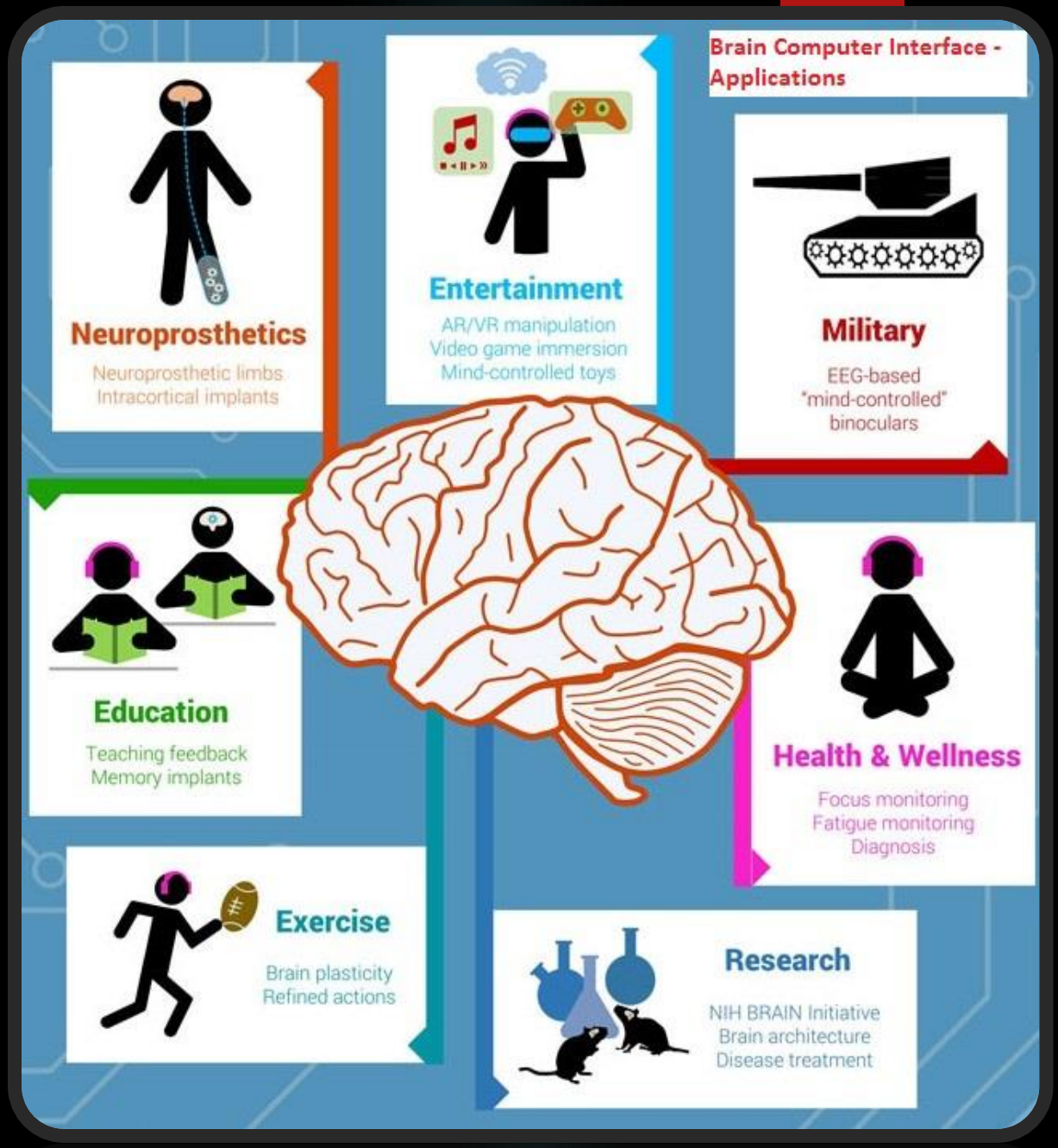


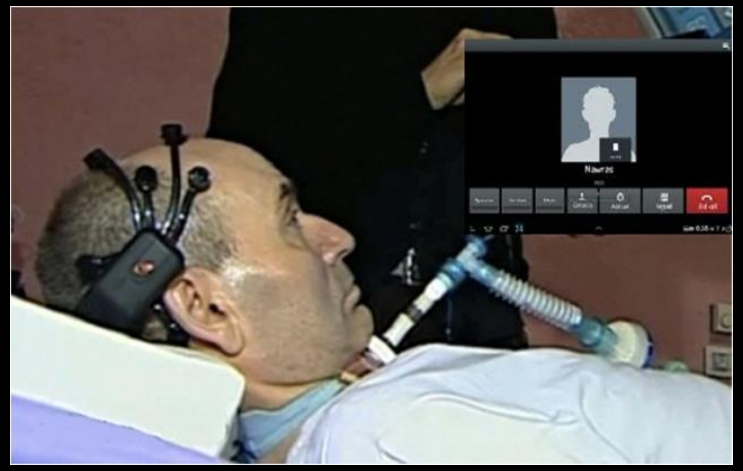
Image Credits: Bablani, Annushree, et al. "Survey on brain-computer interface: An emerging computational intelligence paradigm." ACM Computing Surveys (CSUR) 52.1 (2019): 1-32.

Brain Computer Interaction





Some real-time BCI Applications



Communication

Device Control

Attention Monitoring

Automatic Motion Controlling

Games & Entertainment

Whether BCIs will eventually become as commonplace as current human accessories for sensory and motor augmentation, such as cellular phones and automobiles.????

That remains to be seen.

There are several moral and ethical challenges that society will need to address

History of Brain Computer Interaction

Timeline of BCI

1875

Electrical impulses from a living brain of a rabbit and monkey were recorded for the first time by Richard Caton

1890

Adolf Beck studied the brain activity of animals in response to sensory simulation

1913

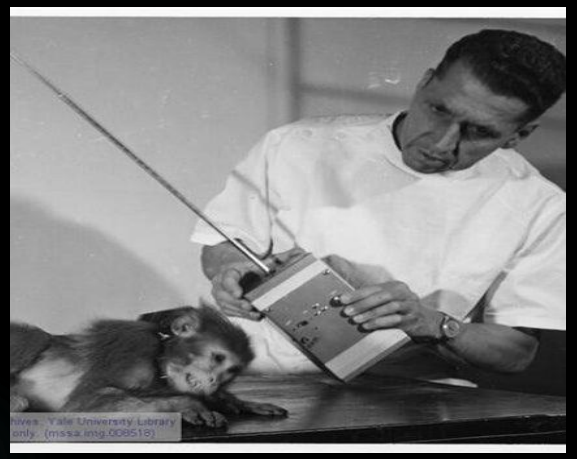
Napoleon Cybulski studied the flow of electric current in muscles using his own capacitor.

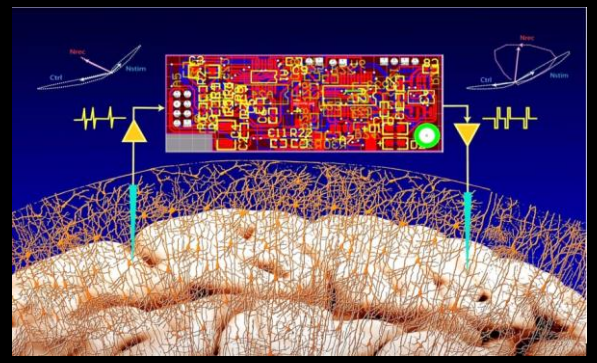
1920

Hans Berger recorded EEG signals from the lesion area of the human scalp for the first time using a Siemens double-coil galvanometer and non-polarized electrodes.

1969

Delgado developed an implantable chip (which he called a “stimoceiver”) that could be used to both stimulate the brain by radio and send electrical signals of brain activity by telemetry, allowing the subject to move about freely.





1969

Dr. Eberhard Fetz showed that neural activity could be used to drive an external device.

1973

Vidal in 1973 explored the use of scalp-recorded brain signals in humans to implement a simple noninvasive BCI based on "visually evoked potentials"

1990

Philip Kennedy had in 1990 developed "invasive" human brain-computer interface, wires inside the brain attached to a computer.

2001

John Donoghue and his team of Brown University in 2001, commercially design a brain computer interface, the so-called BrainGate.

2004

In 2004, Jonathan Wolpaw and researchers at New York State Department of Health's Wadsworth Center demonstrated the ability to control a computer using a BCI.

June 2014

Phil Kennedy implanted electrodes into his brain in order to establish a connection between his motor cortex and a computer

To Study the Brain, a Doctor Puts Himself Under the Knife

How one of the inventors of brain-computer interfaces ended up getting one himself.

- More recently, researchers have begun exploring BCIs for able-bodied individuals for a host of applications such as
  - Games
  - Entertainment to robotic avatars, biometric identification,
  - and Education.

Our Goal in this course

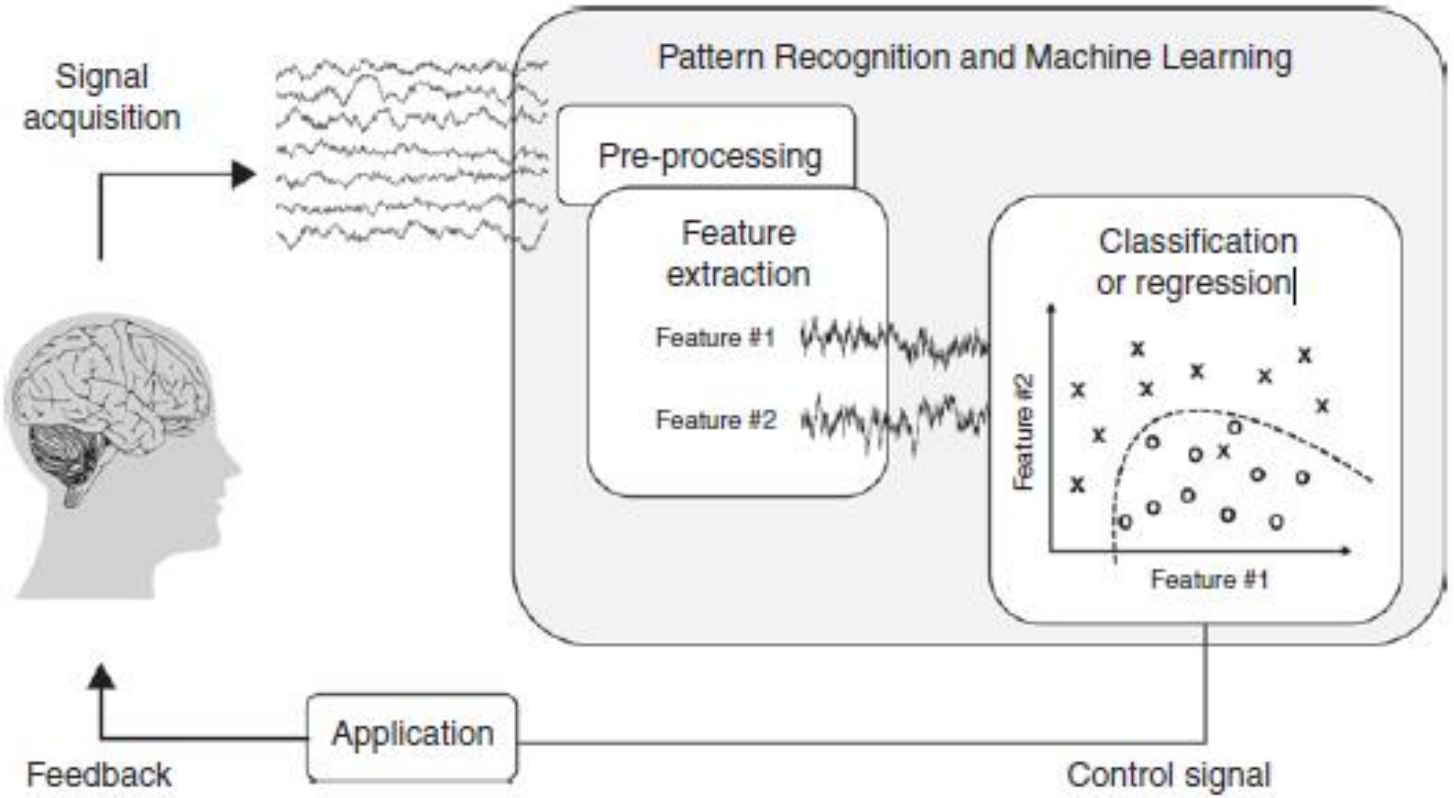
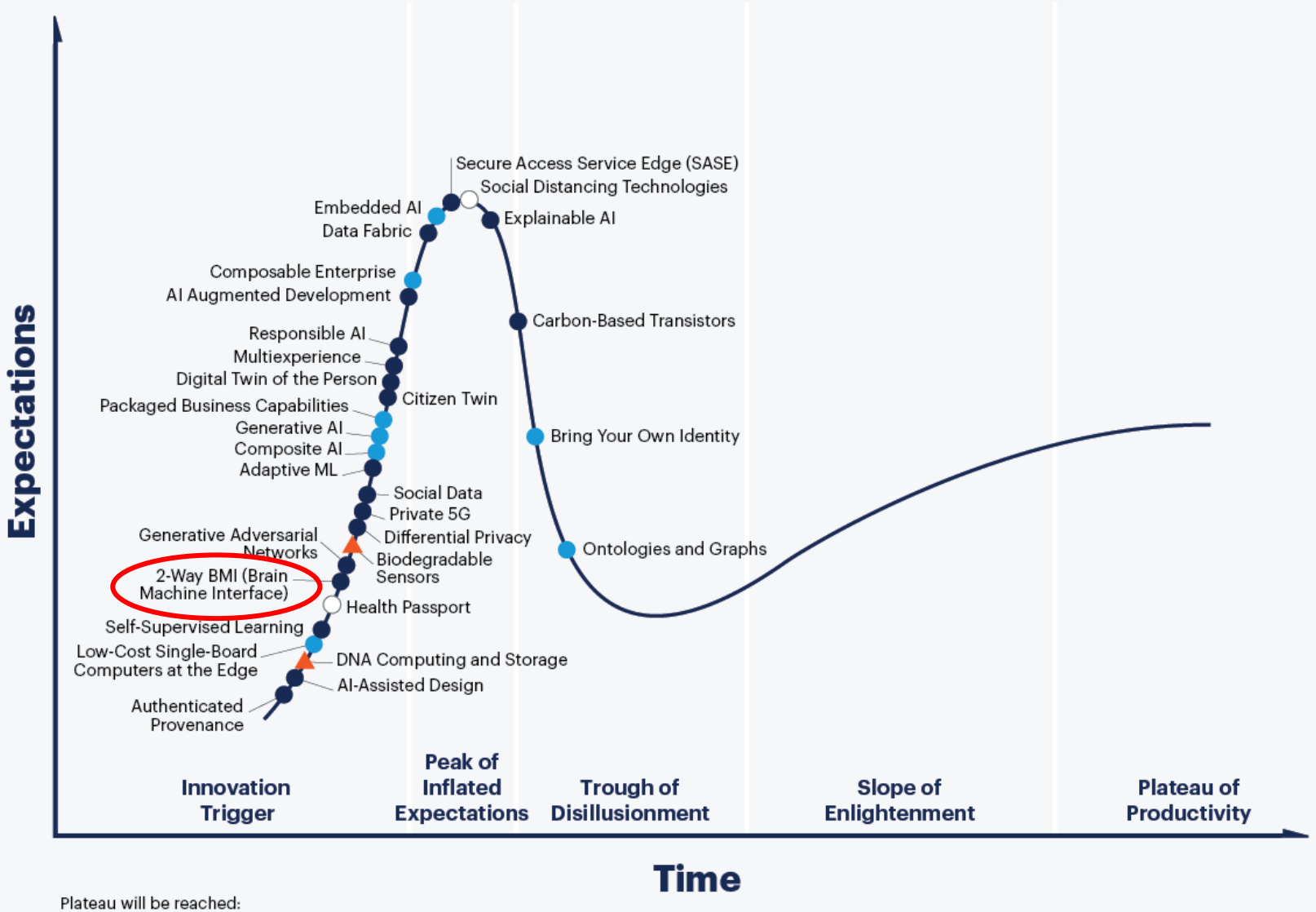


Figure 1.1. **Basic components of a brain-computer interface (BCI).** (Adapted from Rao and Scherer, 2010).

BCI Applications

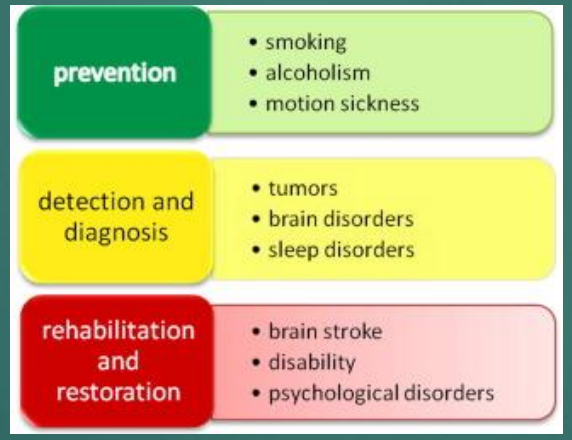
Hype Cycle for Emerging Technologies, 2020



BCI Applications

- Device Control
- User State Monitoring
- Training and Education
- Games and Entertainment.
- Cognitive improvement
- Safety and Security

Medical Applications



Device controls

- For rehabilitation
  - Prosthetic arm
  - Prosthetic legs

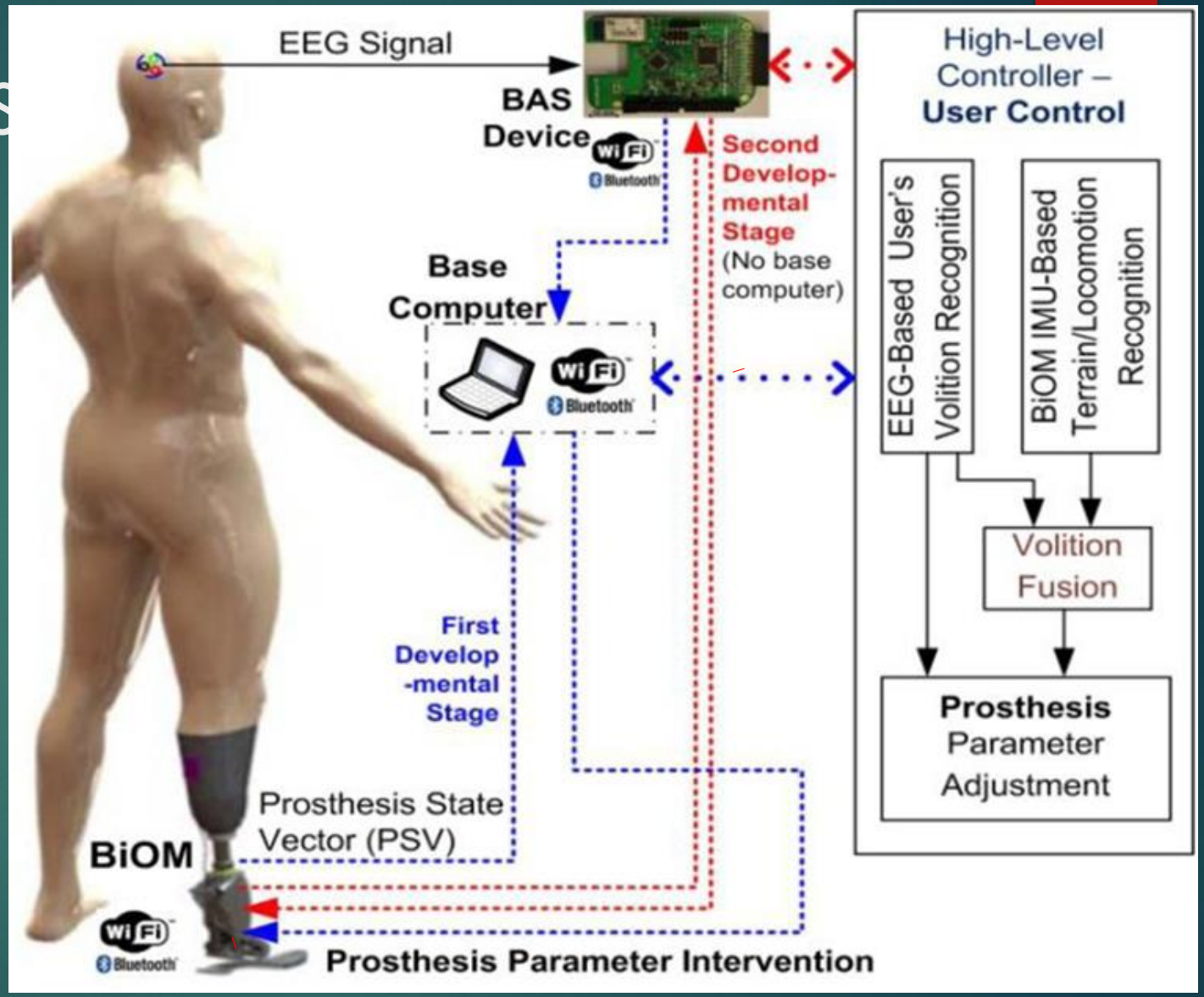
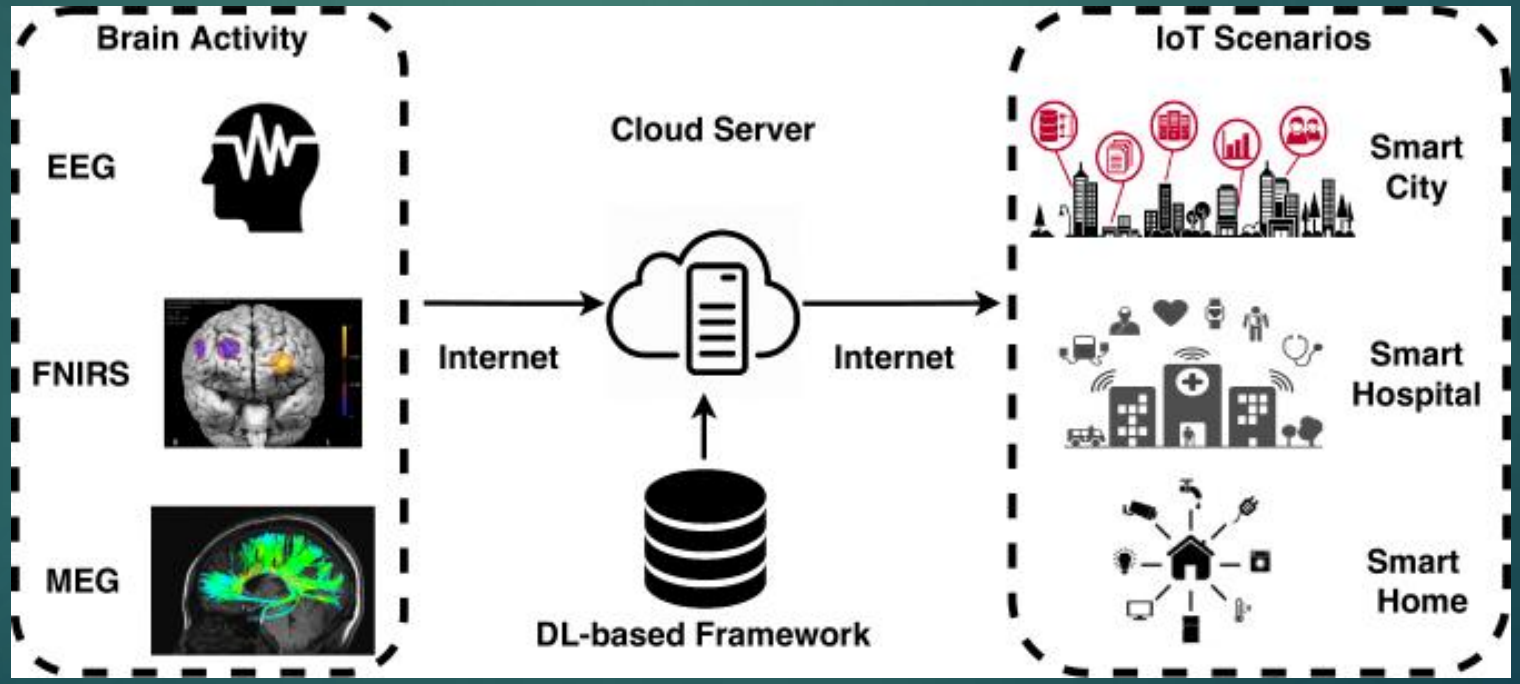


Image credits: https://www.frontiersin.org/files/Articles/308916/fneur-08-00696-HTML/image_m/fneur-08-00696-g001.jpg

Neuroergonomics and smart environment

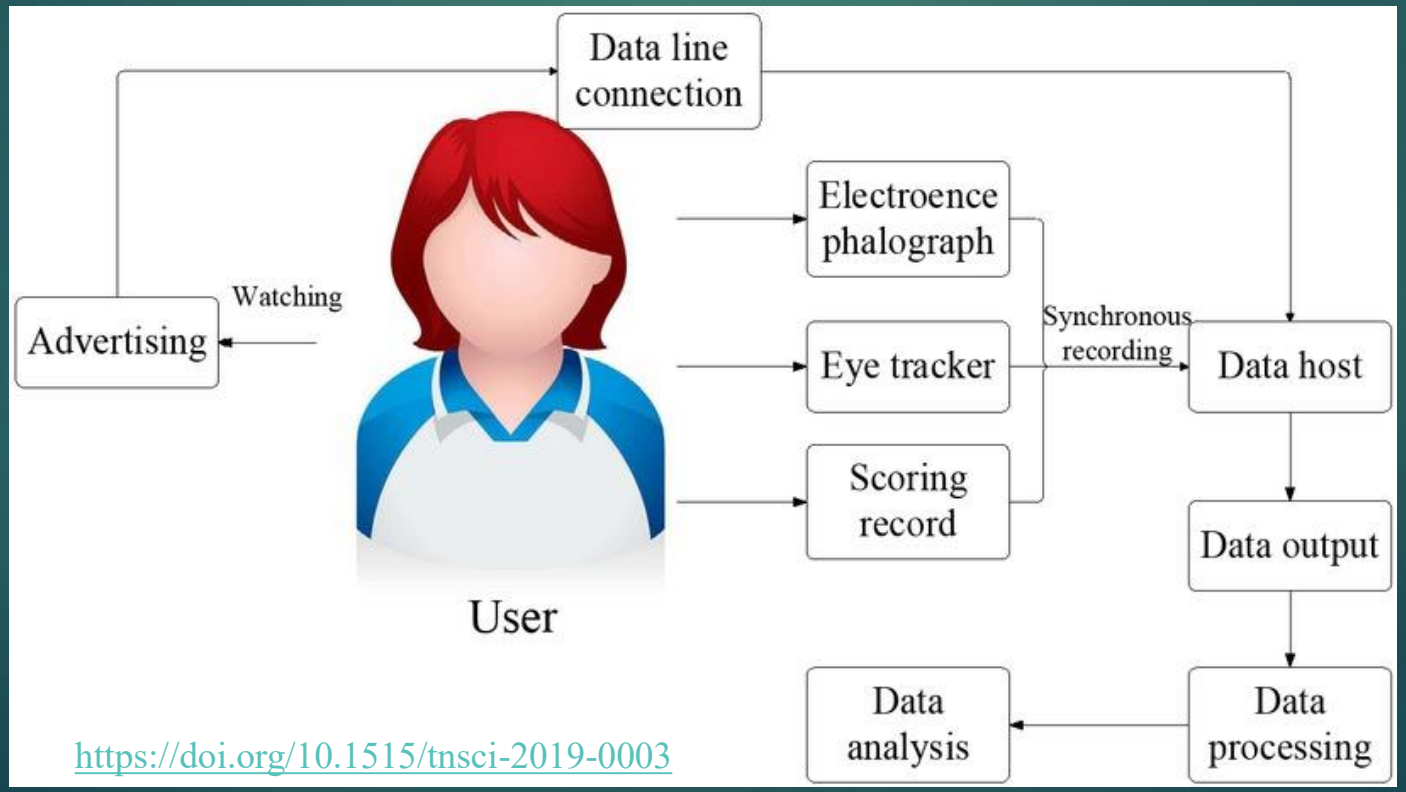
- Cooperation between Internet of Things (IOT) and BCI technologies
- intelligent transportation



by Xiang Zhang, et al. ·

Neuromarketing and advertisement

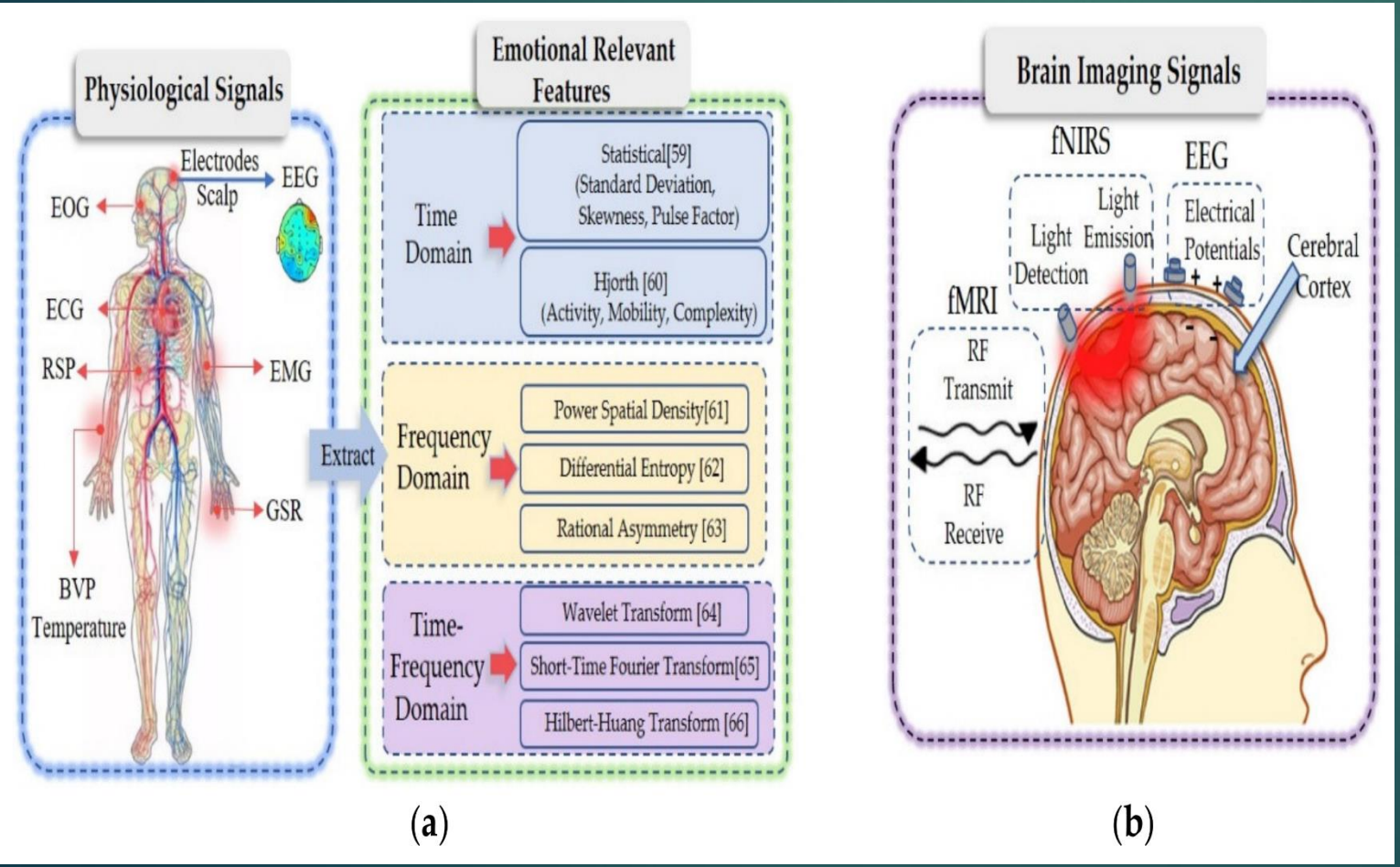
- EEG evaluation for TV advertisements related to both commercial and political fields.
  - The generated attention accompanying watching activity
  - Estimating the memorization of TV advertisements



https://doi.org/10.1515/tnsci-2019-0003

Educational and self-regulation

- Emotional regulation
  - Use of fMRI–EEG BCI to fight the depression feeling as well as other neuropsychiatric disorders



Advances in Multimodal Emotion Recognition Based on Brain–Computer Interfaces
by Zhipeng He

Challenges

- Usability
- Hardware
- Signal processing
- System integration
- Cost